



# FSP Action Plan 2017 - 2021



Government of Tonga

## **FANGA'UTA STEWARDSHIP PLAN (FSP-AP) ACTION PLAN 2017 - 2021**

The 5 year Action Plan is the framework used to organise 'action' in order to achieve the FSP Targets and Objectives. It is a tool to support different FSP stakeholder groups to decide who will do what, how they can best work together, and to prioritise actions and allocate resources. The Action Plan has two sections.

- Section 1 outlines activities against Targets, under each of the FSP Objectives.
- Section 2 provides conceptual frameworks, to guide FSP partners in the development of detailed project proposals. The design of initiatives is a process that is facilitated by the FSP Secretariat, working with key FSP partners, as described under FSP Section 7.

The Action Plan is reviewed annually, as described in FSP Section 8. Amendments are made to the Plan, based on an evaluation of results achieved each year and of lessons learnt. This annual process of review and amendment supports adaptive management: as results are achieved, priorities change, issues change, and new knowledge is generated; there is a corresponding need to amend the actions in the Action Plan to reflect this.

Under the FSP decision making framework:

- Initiatives requiring investment of less than TOP 50,000 can be developed directly by the groups involved including communities, sectoral agencies, NGOs, Private Sector groups, the FSP Secretariat and /or a partnership between these groups. The FSP Secretariat is responsible for reviewing all initiatives to ensure that they contribute directly and effectively towards achievement or one or more of the FSP Targets. This process can occur throughout the year; it is not restricted to the end of year planning meetings.
- Initiatives requiring investment of TOP 50,000 or more must be endorsed by the FSP Steering Committee. This either occurs at their yearly review and planning meeting, or in special circumstances such as for a large project which needs endorsement before the end of the year, a special meeting of the FSP Steering Committee can be called.

The Fanga'uta Stewardship Plan (FSP) establishes the management structure and decision making processes which supports all stakeholder groups to work together in partnership, as stewards of the FLC area.

The following Goal, Objectives and Targets have been agreed by all stakeholders as those towards which 'actions' under this Action Plan must contribute.

**The Goal, Objective and Targets of the Fanga'uta Stewardship Plan are as follows:**

**GOAL:** Stewardship of the Fanta'uta lagoon and catchment area through partnership between individuals, communities, organisations and government agencies, to support sustainable development of the area, and strengthen the resilience of ecosystems and livelihoods; recognising the importance of Fanga'uta lagoon and its' catchment as of national environmental, socio-economic and cultural significance, for current and future generations

**OBJECTIVE 1:** Management and development planning for the Fanga'uta lagoon and catchment area is based on decision making processes which forge partnerships between stakeholder groups, and which are evidence based, consultative, and facilitate enforcement of relevant legislation, supporting sustainable and equitable development of the area.

**TARGET 1i)** A dedicated Secretariat mechanism has been established to support implementation of the 'Fanga'uta Stewardship Plan' providing dedicated support for implementation of the FSP, according to its TOR.

**TARGET 1ii)** Development planning, and associated decision making on infrastructural developments permitted within the FLC area, is based on technical / feasibility assessment, cost / benefit and impact analysis, follows 'due process' in relation to existing legislation, in particular Environmental Impact Assessment (EIA), and includes consultation with stakeholder groups, following the decision-making framework outlined in this Plan'.

**TARGET 1iii)** Implementation of the Fanga'uta Stewardship Plan strengthens the role and capacity of community and district level committees in planning and decision making on sustainable development of the area, supporting Government decentralisation processes.

**TARGET 1iv)** The management structure and processes within the Fanga'uta Stewardship Plan provide a mechanism for consensus based, equitable, and gender sensitive decision making on priority issues, and the initiatives to be supported to address those issues, including resource allocation.

**TARGET 1v)** The Fanga'uta Stewardship Plan, as a legally gazetted management tool, is being used by community and government partners as a mechanism to increase compliance and enforcement of relevant national legislation, in order to achieve the FSP Objectives

**TARGET 1vi)** The value of cultural and historical sites across the Fanga'uta Lagoon and catchment area is considered in land use and development planning, including both their 'existence value' and their potential economic value.

**TARGET 1vii)** The Fanga'uta Stewardship Plan aligns with and supports relevant national plans and policies, including new plans and policies developed over the life of the Plan.

**TARGET 1viii)** The Fanga'uta Stewardship Plan reflects the legislative base for development planning and resource-use management in Tonga.

**Objective 2:** Adaptive Management of the Fanga'uta lagoon and catchment area, through a process which reflects the integrated nature of terrestrial, coastal, freshwater and marine ecosystems, and the activities of people within them, in order to reduce current resource use impacts on ecosystems, preserve key habitats, and ensure the long-term flow of benefits (ecosystem goods and services) to support sustainable and resilient livelihoods.

**TARGET 2i)** Catchment wide monitoring has been undertaken regularly and effectively, as outlined in the FSP monitoring manual, providing stakeholders with the information they need to be able to assess the impacts of current resource use patterns and management processes.

**TARGET 2ii)** Monitoring and evaluation demonstrates the FSP is working to increase the health and resilience of ecosystems across the lagoon, with significant improvements in priority areas, including fish nursery and spawning areas.

**TARGET 2iii)** Monitoring and evaluation demonstrates the FSP is working to increase the health and resilience of ecosystems across the catchment, with significant regeneration in priority areas including mangroves, nesting sites for rare birds and protected areas.

**TARGET 2iv)** Monitoring and evaluation demonstrates that communities (including both men and women) across the FLC area have more resilient and sustainable livelihoods, based on sustainable patterns of resource use and increased livelihood opportunities.

**TARGET 2v)** Eutrophication of the lagoon has been significantly reduced, including through effective measures to address sewage and agriculture related pollution, improving the health of lagoon ecosystems, and of coastal communities.

**TARGET 2vi)** The FSP Evaluation Framework and associated annual review and planning process are being used effectively to support knowledge based, adaptive management of the FLC area, whereby stakeholders learn lessons from successes and failures to make informed decisions, which address priority issues, increase sustainability of resource use and strengthen livelihoods, supporting ecosystem based management of the FLC area.

**TARGET 2vii)** Strengthened partnership and capacity enables communities, government agencies, NGOs and private sector organisations, to work together to identify and address key pressures currently impacting on the health and resilience of ecosystems and livelihoods.

**Objective 3:** Strengthen the commitment of all stakeholders to stewardship of the Fanga'uta lagoon and catchment area, increasing awareness of the importance of sustainable development, and strengthening support for ecosystem based management which incorporates biodiversity conservation and sustainable use strategies, promoting a common understanding of the FSP Goal Objectives and Values

**TARGET 3i)** Increased awareness by all stakeholder groups of the interconnection between people and their environment, and the impact of unsustainable resource use, and of poorly planned development, on the resilience of ecosystems and livelihoods.

**TARGET 3ii)** The establishment of a range of forums and mechanisms which work to increase the commitment of stakeholders to stewardship of the Fanga'uta area, fostering a common understanding of the Core Values, Goal, Objectives and Targets in the Fanga'uta Stewardship Plan.

**TARGET 3iii)** Improved communication channels and increased awareness reduce conflicts over resource use and development in the FLC area, supporting improved partnership for sustainable development at all levels.

## 5 YEAR ACTION PLAN:

### SECTION 1: ACTIONS REQUIRED TO ACHIEVE TARGETS UNDER EACH FSP OBJECTIVE

**FSP OBJECTIVE 1:** Management and development planning for the Fanga’uta lagoon and catchment area is based on decision making processes which forge partnerships between stakeholder groups, and which are evidence based, consultative, and facilitate enforcement of relevant legislation, supporting sustainable and equitable development of the area.

**TARGET 1i)** A dedicated Secretariat mechanism has been established to support implementation of the ‘Fanga’uta Stewardship Plan’

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
<p>Establish FSP Secretariat, with endorsement of its TOR by all three management committees; ensure FSP Secretariat has the resources required to support implementation of the FSP.</p> <p>Budget: <b>\$30,700</b> CMC – 12,200; TWG - \$4,500; PSC - \$4,200; Operational - \$10,000</p>	1	DOE	January to February 2017	FSP Secretariat endorsed and established with clear TOR

**TARGET 1ii)** Development planning, and associated decision making on infrastructural developments permitted within the FLC area, is based on technical / feasibility assessment, cost / benefit and impact analysis, follows ‘due process’ in relation to existing legislation, in particular Environmental Impact Assessment (EIA), and includes consultation with stakeholder groups, following the decision-making framework outlined in this Plan’.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
All development proposals in the FSP area submitted to the FSPS, for review by the three FSP management committees, following the decision-making process outlined in the FSP	1	DOE R2R	January to February 2017	All major infrastructural developments follow FSP decision making procedure including requirement for EIA
All EIAs are undertaken by qualified and certified experts, and are approved by the FSPS and Technical Committee.	1	DOE FSPS	2017-2021	Professional EIAs for all developments which meet international standards.

**TARGET 1iii)** Implementation of the Fanga’uta Stewardship Plan strengthens the role and capacity of community and district level committees in planning and decision making on sustainable development of the area, supporting Government decentralisation processes.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
<b>Budget – Training \$57,200</b>				
MIA Community Development & Local Governance Department provide support for the establishment of community and district level committees /groups in the FLC area.	1	MIA CDG	2017 -2021	Increased number of community and district level committees supporting initiatives under the FSP
MIA Community Development & Local Governance Department, Civil Society Forum, & Chamber of Commerce support training for community and district committees in FLC area, based on capacity needs assessment.	2	MIA- CD&Gov Division	2017 - 2021	Increased capacity of community and district level committees in FLC area

**TARGET 1iv)** The management structure and processes within the Fanga’uta Stewardship Plan provide a mechanism for consensus based, equitable, and gender sensitive decision making on priority issues, and the initiatives to be supported to address those issues, including resource allocation.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
<b>Budget - \$20,000</b>				
Consultation with stakeholder groups to develop a Resourcing Strategy for implementation of key action areas under the FSP. This should be based on an assessment of current capacities, and resource availability. It should enable partners in the FSP to reach agreement on a range of mechanisms to support FSP implementation including: community self-help; Govt sectoral agency support through annual budgets and work plans; private sector inputs; NGO support, and donor funded initiatives.  Develop guidance on donor funding opportunities.	1	DOE / R2R	2017	Publication of an FSP resourcing strategy and guidelines on funding opportunities.
Prior to and following CMC meetings, Town and District Officers work directly with local and district level committees, to consult on key issues, discuss proposed	1	CMC members	2017 - 2021	Annual surveys indicate that community members have

initiatives and to report back on CMC meeting conclusions; this ensures that the views of community stakeholders (both men and women) are effectively represented within the CMC.				been consulted on all key issues & that CMC members have represented their interests effectively.
MIA's Women's Affairs Division, the Women's Council for Tonga and Civil Society Forum provide support to women's groups across the FLC area, to build their capacity for engagement in management and decision making, so that issues of concern to women are considered by the three management committees, and initiatives supported under the FSP provide support to women.	1	MIA Women's Council Civil Soc Forum	2017 -2021	Monitoring surveys confirm that women's concerns are being effectively addressed.

**TARGET 1v)** The Fanga'uta Stewardship Plan, as a legally gazetted management tool, is being used by community and government partners as a mechanism to increase compliance and enforcement of relevant national legislation, in order to achieve the FSP Objectives.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
FSP gazetted by the Minister of Environment	1	DOE	January 2017	FSP Gazetted
Appoint and provide training to Environment Enforcement Officers in FLC priority areas.	2	DOE	March – December 2017	Enforcement Officers appointed and enforcing relevant regulations
Establish a confidential reporting mechanism to enable concerned citizens to report breaches of the law.	2	DOE / CMC	2017	Mechanism established which enables citizens to report breaches of the law to DOE or enforcement officers

**TARGET 1vi)** The value of cultural and historical sites across the Fanga'uta Lagoon and catchment area is considered in land use and development planning, including both their 'existence value' and their potential economic value.

Action	Priority (1 – 3)	Lead Agency	Timeframe	Indicator of Success
<b>Budget - \$7000</b>				

Undertake a survey of cultural and historical sites across the FLC area, develop a map of these sites and share relevant information with communities. Integrate sites and information in to existing baseline 'synchronised map' of FLC.	2	GIS	2017	Integrated map
FSP management committees consider cultural and economic value of sites in development planning for FLC area.	2	CMC TC SC	2017-2021	Decision making considers cultural & archaeological values

**TARGET 1vii)** The Fanga'uta Stewardship Plan aligns with and supports relevant national plans and policies, including new plans and policies developed over the life of the Plan.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
<b>Budget - \$10,000</b>				
Annual review of the FSP assesses the implications of any new national plans and policies; the FSP Secretariat and FSP Committees provide recommendations on any amendments required.	1	FSPS CMC TC SC	2017 - 2021	Annual evaluative review incorporates assessment of any new national plans and policies on FSP

**TARGET 1viii)** The Fanga'uta Stewardship Plan reflects the legislative base for development planning and resource-use management in Tonga.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
Annual review of the FSP assesses the implications of any new legislation; the FSP Secretariat and FSP Committees provide recommendations on any amendments required	1	FSPS CMC TC SC	2017 - 2021	Annual evaluative review incorporates assessment of any new national legislation on FSP

**Total Budget for Target 1: TOP\$124,900**

**Objective 2:** Adaptive Management of the Fanga’uta lagoon and catchment area, through a process which reflects the integrated nature of terrestrial, coastal, freshwater and marine ecosystems, and the activities of people within them, in order to reduce current resource use impacts on ecosystems, preserve key habitats, and ensure the long-term flow of benefits (ecosystem goods and services) to support sustainable and resilient livelihoods.

**TARGET 2i)** Catchment wide monitoring has been undertaken regularly and effectively, as outlined in the FSP monitoring manual, providing stakeholders with the information they need to be able to assess the impacts of current resource use patterns and management processes.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
<b>Budget: M&amp;E - \$40,000, Reporting - \$20,000</b>				
Monitoring undertaken according to the schedule outlined in the monitoring framework, following the monitoring manual, and according to the monitoring teams’ TOR. Summary reports submitted by each monitoring team to the FSP Secretariat in October each year.	1	FSP Monitoring Teams	2017 -2021	Monitoring data regularly collected and reports submitted to FSPS
Annual review of monitoring framework & manual to ensure that monitoring data is providing the information required for effective evaluation, to support ecosystem based management. Amendment of monitoring framework if necessary; for example: if new issues such as invasive species (IAS) are found to be a key threat to lagoon or terrestrial areas, it may be necessary to include monitoring of IAS within the monitoring framework. Lessons may also be learnt by the monitoring teams to improve survey & assessment approaches or techniques.	1	FSP Monitoring Teams FSPS	2017 - 2021	Annual review of monitoring framework. Amendments where necessary.
Training delivered to new monitoring staff in relevant government departments, if required, to ensure capacity is built / maintained for effective monitoring in FLC area.	1	FSP Monitoring Teams	2017-2021	Training courses delivered. Monitoring data collected effectively and efficiently.
Training delivered to community groups to enable them to contribute to monitoring in relevant areas, as outlined in the monitoring manual.	1	FSP Monitoring Teams	2017 - 2021	Training courses delivered. Monitoring data collected effectively and efficiently.

**TARGET 2ii)** Monitoring and evaluation demonstrates the FSP is working to increase the health and resilience of ecosystems across the lagoon, with significant improvements in priority areas, including fish nursery and spawning areas.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
Implementation of SMAs, including capacity building of community management committees for local area management. \$2000	1	DOF	2017-2021	SMAs managed effectively; monitoring data indicates improvements
Mangrove replanting initiatives Maintenance of mangrove nurseries and regeneration areas \$20,000		Community Committees DOE & R2R	2017-2021	Mangrove nurseries and regeneration areas are maintained. Replanting initiatives continued.
Negotiation with Ministry of Lands, Survey and Natural Resources, and individuals to whom Nukuhetulu mangrove areas have been allocated, to find alternative solution, in order to preserve these key mangrove areas. Declaration of Nukuhetulu mangroves as protected areas, and subsequent support to establish effective protection measures.		DOE & R2R	January 2017	Declaration of mangrove areas at Nukuhetulu as protected, with appropriate management measures in place.
Assessment of reasons for mass mangrove die off at Nukuhetulu, including assessment of the impact of the raised road level, and of reclamation of large area for a sports field, to determine if this has altered natural water flow between Folaha marshland and the lagoon and consequently affected mangrove areas. Implementation of appropriate actions to revive mangrove areas.		DOE & R2R	January / February 2017	Assessment undertaken; Remedial action. Monitoring demonstrates regeneration of area.
Survey of lagoon ecosystems to determine the presence, and if present, impact, of sub-marine invasive species. Implementation of appropriate action to remove, control and manage lagoon IAS if present.	2	DOE	2017 / 2018	Survey undertaken; Control of IAS if required.
Hydrological survey undertaken to assess the impact of water movement on lagoon ecosystems and the implications for patterns of erosion and deposition.	2	DOE & R2R	February / March 2017	Hydrological survey; results circulated to management committees & affected stakeholders to guide decision making.

**TARGET 2iii)** Monitoring and evaluation demonstrates the FSP is working to increase the health and resilience of ecosystems across the catchment, with significant regeneration in priority areas.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
Clean and maintain freshwater springs; <b>\$20,000</b> Assess causes of flow reduction at springs, including water usage at boreholes inland of springs, and recommend actions. Remedial action undertaken	2	Communities DOE	2017-2021 2017-2018	Clean and well maintained springs used by communities.
Assessment of pesticide / fertiliser use & impact across the FLC catchment area. Provide advice to farmers on safe and environmentally sound use of pesticides, chemicals and fertilisers, including clear guidelines & information on legislation. Establish management & control system, including farm checks and Environmental Enforcement Officers. <b>\$5000</b>	1	MAFF	2017-2021	Safer practices. Reduced pollution of agricultural lands / ground water by pesticides & fertilisers.
Work with Tonga Forest Products and Dumps in the FLC area, to improve environmental management and reduce the quantity of leachates escaping.	1	DOE	2017 -2018	Reduced pollution from leachates.
Establish community waste management action groups, and rubbish clean up days in order to reduce illegal dumping of rubbish and continue to clean up areas. <b>\$5000</b>	2	Communities DOE & R2R	2017 -2018	Reduced amount of rubbish and reduced illegal dumping
Undertake a survey of the presence and impacts of invasive species (IAS) on coastal and catchment land areas, and of options for effective management & control. Build capacity for effective IAS management & control across FLC area. <b>Refer to amount on M&amp;E</b>	2	DOE	2017-2021	Improved knowledge of IAS in FLC area and improved management & control.
Replant native trees and plants in coastal areas to improve the diversity of species and increase the resilience of coasts. <b>\$20,000</b>  Designate reserve areas across FLC for trees and plants that are used for local medicines and traditional practices. Establish locally managed, sustainable use systems. An example of this could be the establishment of specially managed mangrove areas for tapa, medicinal use and firewood (similar to the SMA approach with community management committees, to oversee use restrictions)	2	DOE / MAFF Forestry Div	2017-2021	Diversity of native plant and tree species increased. Sustainably managed areas established.
IAS removal, management and control in Taloa rainforest and sustainable	2	DOE / MAFF	2017-2021	Reduced impact of IAS in

management of the area, as Tonga's largest remaining area of rainforest. \$5000		Forestry Div		Taloa and improved management.
Bird conservation actions: To be determined once R2R bird survey completed	TBD	TBD	TBD	TBD

**TARGET 2iv)** Monitoring and evaluation demonstrates that communities (including both men and women) across the FLC area have more resilient and sustainable livelihoods, based on sustainable patterns of resource use and increased livelihood opportunities.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
Design and implement initiatives across the FLC area to support communities to establish more sustainable livelihoods. This could include: \$40,000 - Support for farmers to establish organic, permaculture or agro-forestry businesses, including establishment of certification schemes, farm management / control systems, the development of high value markets, or connection to existing markets. - Support for communities to establish tourism initiatives, including eco-tourism and cultural / historical tourism at springs or archaeological sites.	1	DOE MIA  DOA  DOT	2017-2021	Initiative(s) designed through FSP process, and being implemented to support communities to establish more sustainable and resilient livelihoods.
Training / capacity building of women's committees across the FLC area to establish a range of sustainable livelihood related skills. This could include support from: the Women's Council for Tonga (Langafonua a Fafine) who provide training for women's groups in crafts and in business skills development; the women and extension division of MAFF; MIA's Women's Affairs Division; and from the Chamber of Commerce who offer a range of skills development courses. \$20,000	1	MIA MAFF	2017-2021	Women across the FLC confirm they have increased skills and knowledge.
Training / capacity building of youth groups across the FLC area, increasing the skill and knowledge base of young people, to inspire and enable them to engage in environmental management and establish sustainable livelihoods.	1	DOE & MIA Youth groups	2017 -2021	Number of active youth groups and number of young people engaged in initiatives.
Support to coastal communities to address erosion issues. This will include assessment of the reasons for increased erosion in the most affected areas, based on the hydrological survey; and the assessment of potential solutions.	1	DOE MIA	2017 - 2021	Reduced erosion

**TARGET 2v)** Eutrophication of the lagoon has been significantly reduced, including through effective measures to address sewage and agriculture related pollution, improving the health of lagoon ecosystems, and of coastal communities.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
<b>Budget - \$7000</b>				
Identify and implement a long-term solution to sewage related nitrification of the lagoon, develop a detailed proposal and source funding for implementation. Options include: - Centralised, reticulated sewage system with ocean outfall (long term solution) - Improved septic systems, to ensure tanks don't leak, and sludge is safely disposed (will reduce current pollution levels)  (Consultation with the sanitation sub project under the Nuku'alofa Urban Development Sector Project who may be able to provide support)	1	DOE	2017 -2018	Efficient and safe sewage treatment and disposal system established  Monitoring shows reduced eutrophication of the lagoon
Support initiatives working with farmers to manage / control use of NPK fertilisers to reduce the quantity of nitrates entering ground water / the lagoon.	1	DOA & DOE	2017 - 2021	Monitoring shows reduced nitrates entering the lagoon from agricultural sources

**TARGET 2vi)** The FSP Evaluation Framework and associated annual review and planning process are being used effectively to support knowledge based, adaptive management of the FLC area, whereby stakeholders learn lessons from successes and failures to make informed decisions, which address priority issues, increase sustainability of resource use and strengthen livelihoods, supporting ecosystem based management of the FLC area.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
<b>Budget - \$15,000</b>				
Annual Evaluation Report completed by FSP Secretariat and circulated to all management committees ahead of end of year review and planning meetings.  Summary information leaflet circulated, through CMC, to FLC communities.	1	FSPS	November 2017 –2021	Annual Evaluation Report completed and used as basis for planning.
Decision making on initiatives and developments in the FLC area follows the adaptive management process outlined in the FSP; it is based on annual review of the Evaluation Report by the three management committees to	1	FSPS & FSP management committees	November- December each year	Annual Evaluation process used as basis for planning, supporting adaptive

assess the effectiveness of actions undertaken, and lessons learnt, which in turn informs prioritisation of Actions/Initiatives for the following year.			2017 - 2021	management.
Review of Evaluation Framework and process, after three years, to ensure it is providing the analysis and information required for adaptive management of the area.	1	FSPS & FSP management committees	2019	Review of Evaluation Framework completed.

**TARGET 2vii)** Strengthened partnership and capacity enables communities, government agencies, NGOs and private sector organisations, to work together to identify and address key pressures currently impacting on the health and resilience of ecosystems and livelihoods.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
<b>Budget - \$5000</b>				
Launch of the FSP through a multi-stakeholder workshop, supporting all stakeholder groups to come together to celebrate the launch of the Plan, confirm partnerships and their commitment to effective implementation of the Plan	1	DOE R2R	February 2017	Workshop held and attended by key stakeholder groups.
Support at all levels to ensure implementation of the FSP brings the range of stakeholders in the FLC area together to address key issues and decide on management measures and initiatives to support sustainable development of the area.	1	FSPS	2017-2021	Consultation with stakeholder groups within annual monitoring.
Consultation with and direct involvement of all relevant community and district level committees in the design and implementation of initiatives/projects, to ensure that initiatives and actions are well designed and have strong ownership by local stakeholders.	1	FSPS / MIA	2017 - 2021	Design of all new initiatives involves consultation with community and district level committees.

**Total Budget for Target 2: TOP\$224,000**

**Objective 3:** Strengthen the commitment of all stakeholders to stewardship of the Fanga’uta lagoon and catchment area, increasing awareness of the importance of sustainable development, and strengthening support for ecosystem based management which incorporates biodiversity conservation and sustainable use strategies, promoting a common understanding of the FSP Goal Objectives and Values.

**TARGET 3i)** Increased awareness by all stakeholder groups of the interconnection between people and their environment, and the impact of unsustainable resource use, and of poorly planned development, on the resilience of ecosystems and livelihoods.

Action <b>Budget \$30,000</b>	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
<p>Raise the awareness of all stakeholders on the resource use, development planning and management implications of the ‘Fanga’uta Stewardship Plan’ to ensure Government agencies, communities, district committees, NGOs and private sector organisations have a good understanding of the FSP and its implications for the way in which they work, the livelihood choices they make, the way decisions are to be made in the area, and the opportunities available to them.</p> <p>Key resource use issues include:</p> <ul style="list-style-type: none"> <li>- Mangroves, and mangrove use;</li> <li>- Safe sewage disposal</li> <li>- Safe rubbish disposal</li> <li>- The impact of free roaming pigs</li> <li>- Erosion</li> <li>- Invasive Species (IAS), their impacts, high risk species and routes for introduction.</li> <li>- Poorly planned infrastructural development</li> </ul>	1	DOE R2R	2017-2021	Monitoring surveys within annual evaluation indicate increased awareness of all groups.
<p>Awareness raising program implemented for all FSP stakeholders to increase understanding of relevant Environmental legislation, why compliance is important for sustainable development of the area, and the role and mandate of Environment Enforcement Officers. This could include:</p> <ul style="list-style-type: none"> <li>- Distribution of information leaflets providing clear guidance and information to</li> </ul>	1	DOE R2R	January to March 2017	Increased awareness of coastal communities and local businesses on requirement for EIA

<p>Community and District Committees, Town and District Officers, Police and Enforcement Officers, on the legal basis for enforcing the Fanga’uta Stewardship Plan, so as to ensure communities are well informed and have the knowledge to abide by and enforce management measures across the area. (for example guidance on EIAs, the Waste Management Act; Fisheries Regulations; Agriculture regulations; Environment Management Act; Water Resources Act; Building Control Standards etc)</p> <p>- Awareness raising for business operators in the FLC area, to ensure that all understand the legal requirement for Environmental Impact Assessment (EIA) on all major infrastructural developments.</p>				
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**TARGET 3ii)** The establishment of a range of forums and mechanisms which work to increase the commitment of stakeholders to stewardship of the Fanga’uta area, fostering a common understanding of the Core Values, Goal, Objectives and Targets in the Fanga’uta Stewardship Plan.

<b>Action</b>	<b>Priority (1 – 3)</b>	<b>Lead</b>	<b>Timeframe</b>	<b>Indicator of Success</b>
<p>Establishment of an annual Fanga’uta Festival to support sharing of lessons and success stories, the sale of handicrafts and produce, and the vision of achieving an FLC area that is a resilient, sustainable and dynamic interaction of people and their environment. \$10,000</p>	1	DOE R2R	2017	Establishment of Fanga’uta Festival
<p>The use of a range of media to support education and awareness raising at all levels including through TV, radio and SMS, public education, school activities and curriculum, continuing the initiatives established under the R2R project.</p> <p>Explore opportunities for sponsorship of awareness raising through TV and Telephone companies and Radio Stations, following the end of the R2R project.</p> <p>Explore opportunities to incorporate environmental activities into school curricula / practices for schools in FLC area (eg increased field trips and environmental activities)</p>	2	DOE R2R	2017-2021	Continued education and awareness raising.
<p>The engagement of local committees and action groups in awareness raising</p>	2	DOE R2R	2017-2021	Continued / strengthened engagement of community

initiatives, including youth groups and drama groups.				groups
Establishment of district 'lagoon watch' in coastal areas, which brings coastal communities together, supported by technical experts from relevant Government Departments, to discuss and support a healthy lagoon and livelihoods \$15,000	2	DOE R2R	2017	Lagoon watch established

**TARGET 3iii)** Improved communication channels and increased awareness reduce conflicts over resource use and development in the FLC area, supporting improved partnership for sustainable development at all levels.

Action	Priority (1 – 3)	Lead	Timeframe	Indicator of Success
Establish the conflict resolution mechanism outlined under the FSP including: District level fora for discussion / solution of all concerns and conflicts related to natural resource use and development within FLC Districts; and involvement of FSPS and the 3 FSP management committees for solution of all FLC wide disputes.	2	FSPS / R2R	2017	Conflict resolution operating following procedure outlines in FSP; Conflicts over resource use / development resolved effectively.
Provide support to community management committees within SMAs to resolve any conflicts over fisheries access.	2	DOF	2017-2021	Conflicts resolved
Communicate results of EIAs to all communities affected by proposed infrastructural developments; Consultation by CMC members to ensure affected communities have a 'voice' in decision making on proposed infrastructural developments.	1	DOE FSPS CMC	2017-2021	Effective communication of results of EIAs to affected communities & consideration of community opinions in decision making.
Development of information leaflet on all legislation relevant to FSP for distribution to FLC communities, private sector groups, and government agencies, to increase awareness and understanding amongst all stakeholders of what is allowed and what isn't, and why.	1	DOE R2R	2017	Information leaflet distributed Monitoring Surveys indicate increased awareness of legal basis for management.

**Total Budget for Target 3: TOP\$55,000**

**Total Budget Action Plan by output: \$124,900 + \$224,000+ \$55,000 = TOP\$403,900/year**

## ACTION PLAN SECTION 2: CONCEPTUAL FRAMEWORKS TO GUIDE THE DESIGN OF FSP INITIATIVES / PROJECTS

To following frameworks, provide guidance to FSP partners in the conceptualisation and design of initiatives to support implementation of the FSP.

### Initiative 1: R2R Project – Actions to consider for inclusion in 2017 work plan

<b>Objectives to which proposed Action contributes:</b> Objectives 1, 2 and 3	
<b>Targets to which proposed Action contributes:</b> Objective 1, all Targets; Objective 2 Targets 2i to 2iv, 2vi & 2vii; Objective 3, all Targets	
<b>Management Issue:</b> All management issues highlighted in FSP	
<p><b>Actions Proposed:</b></p> <p><b>Support for launch of FSP:</b> including finalisation of FSP and publication / distribution. Workshop with participation by all stakeholder groups to launch the FSP; Development of information leaflets on FSP for distribution to communities across FSP</p> <p><b>Establish functioning FSP Management Mechanism:</b> support for implementation of FSP during its first year (including support for evaluation /planning at the end of FSP year 1 – December 2017)</p> <p><b>Development of information leaflet on legislation relevant to FSP for distribution to FLC communities</b></p> <p><b>Development of a resourcing strategy for sustainable implementation of the FSP.</b> This would be developed based on broad consultation with all key stakeholder groups, building on the FSP and associated Action Plan, in order to identify existing capacities and resource availability. The resourcing strategy will identify and enable FSP partners to agree on action areas:</p> <ol style="list-style-type: none"> <li>that can be largely achieved through community self-help</li> <li>that will require ongoing Got sectoral support and commitment, to be incorporated in to sectoral workplans and budgets;</li> <li>that offer opportunities for private sector support, identifying avenues to achieve private sector inputs</li> <li>that offer opportunities for NGO support (including international NGOs);</li> <li>that may be most effectively addressed through donor funded ‘projects.’ Associated guidance could</li> </ol>	<p><b>Anticipated Impact Level</b></p> <p><i>Social (1-5): 5</i></p> <p><i>Environmental (1-5): 5</i></p> <p><i>Management (1-5): 5</i></p>

be developed on potential sources of donor funding (for example through Green Climate Fund; UNDP-GEF; AusAID; ABD; WB; EU; Regional Pacific funds etc)

**Ongoing awareness raising initiatives:** support to continue awareness raising initiatives and to secure the sustainability of these initiatives through sponsorship by private sector, incorporation in to Govt budgets, local self-help etc

**Ongoing support for mangrove replanting / nurseries** to secure the sustainability of these initiatives through incorporation in to Govt budgets, local self-help etc

**Hydrological assessment:** undertaken to assess the impact of water movement in the lagoon on siltation and coastal erosion. Results from the survey would inform decision making on how to address coastal erosion, and whether to commission further assessments (including EIA) to look at the potential impacts, risks and cost/benefits of options such dredging or suction methods which have been proposed to reduce silt in the lagoon.

**Ongoing capacity building for community groups:** including with MIA Community Development and Governance Programme, and Tonga Women's Council to establish community committees and to build their capacity.

**Establish Fanga'uta Festival:** The establishment of an annual Fanga'uta Stewardship Festival that would increase awareness of sustainability issues, enable sharing of lessons and success stories, provide an avenue to support livelihoods through the sale of handicrafts and produce, and support celebration of the vision of 'Fanga'uta' as a resilient, sustainable and dynamic interaction of people and their environment.

**Address current threats to Nukuhetulu mangroves and support remedial action,** recognising the importance of this area:

- Assess reasons for mangrove die back, including the impact of the road and sports ground in reducing water and nutrient flow to the Nukuhetulu mangrove area; undertake remedial action.
- Facilitate negotiation with Ministry of Lands, Survey and Natural Resources, and individuals who have been allocated mangrove areas for reclamation.
- Undertake further assessments of the current patterns of use of Nukuhetulu Mangroves to identify key resource use pressures.
- Establish protected / managed 'stewardship areas' including: enforcement of managed use; support for alternative livelihoods / alternative harvesting areas; mangrove replanting; monitoring control and surveillance.

<p><b>Undertake Survey to confirm archaeological sites surrounding Fanga'uta lagoon and incorporation in to synchronised map</b></p> <p><b>Ongoing support to livelihood initiatives</b> already being supported under R2R, including to revive fresh water springs, establish associated community based tourism enterprise. Assess causes of flow reduction at springs, including water usage at boreholes inland of springs, and support remedial action.</p> <p><b>Appoint and provide training to Environment Enforcement Officers:</b> Under the Environment Management Act 2010, The Minster may appoint any person whether employed in the Ministry or otherwise to be an Environment Officer for the purposes of the Act. Environment Officers have the power to enforce the Act, or any other law relating to the protection or management of the environment; monitor the impact of any activity; investigate whether an offence has been committed; and seize property reasonably suspected of being used in relation to adverse impacts on the environment. A range of penalties are available at the discretion of Environment Officers including fines; requirement to pay a monitoring levy; requirement for environmental rehabilitation; order to cease any activity deemed to be having a negative environmental impact; environment infringement notice; stop work notice; requirement to pay compensation or environmental reinstatement costs; imprisonment.</p>	
<p><b>Lead Responsibility for design / implementation:</b> R2R with DOE, the CMC, Technical Committee &amp; Steering Committee; &amp; once established FSPS</p> <p><b>Key Partners:</b> All current partners in R2R project</p>	
<p><b>Resource considerations:</b> Existing R2R budget for 2017; R2R Team to assess whether budget is adequate for all activities proposed, and if not whether there is any option to access additional resources, and /or extend the project timeframe.</p>	
<p><b>Risks and level of Risk:</b> Minimal risk given resource allocation already agreed for R2R and commitment of all key stakeholder groups.</p>	
<p><b>Proposed Timeframe to initiate:</b> January 2017  <b>Anticipated Timeframe to complete:</b> December 2017 (it would be useful to explore options for an extension in project timeframe)</p>	
<p><b>Monitoring:</b> Ongoing monitoring of R2R project following UNDP-GEF procedures; monitoring of FSP impacts by FSP Monitoring Teams following guidelines, monitoring manual and their TOR.</p>	
<p><b>Impact Evaluation:</b> End of project evaluation by UNDP-GEF following normal procedures; Annual evaluation of FSP following FSP procedures.</p>	
<p><b>Further Notes and Comments:</b></p>	

The final year of the R2R project will provide key support for the launch of the FSP, and to secure the sustainability of the FSP management process, and initiatives being implemented under it.

## New Projects / Initiatives

### Initiative 2: Prevention, control & management of Invasive alien species (IAS) threats to ecosystems and livelihoods in the FLC area.

<b>Objective to which proposed Action contributes:</b> Objective 2	
<b>Target to which proposed Action contributes:</b> Target 2ii; 2iii; 3i;	
<b>Management Issue:</b> Invasive Alien Species threats and impacts to Fanga'uta lagoon and catchment area	
<b>Action / Initiative Proposed</b> Design of a project to <ul style="list-style-type: none"> <li>a) assess IAS in Fanga'uta lagoon and across the catchment area.</li> <li>b) Increase awareness on IAS</li> <li>c) Develop and implement a strategy for FLC, to control and manage existing IAS and prevent their introduction.</li> </ul> Support implementation of the National Invasive Species Strategy and Action Plan (NISSAP) output: Feasibility study on the Rehabilitation Fanga'uta Lagoon and Fangakakau Lagoon Marine Reserve	<b>Anticipated Impact Level</b> (currently not possible to determine as the impact of the initiative will depend on the extent of / level of impact of IAS in FLC area)
<b>Lead Responsibility for design / implementation:</b> DOE – FSPS with the FSP management committees following the design and decision making process outlined in the FSP.	
<b>Key Partners:</b> To be determined in project design	
<b>Resource considerations:</b> To be determined in project design	
<b>Risks and level of Risk</b> To be determined in project design	
<b>Proposed Timeframe to initiate:</b> To be determined in project design <b>Anticipated Timeframe to complete:</b> To be determined in project design	
<b>Monitoring:</b> To be determined in project design	

**Impact Evaluation:** To be determined in project design

**Further Notes and Comments:** There may be opportunities for support under a phase 2 of the GEF-UNEP Tonga Invasive Alien Species Project.

### Initiative 3: Support for Implementation of the Fanga'uta Stewardship Plan (FSP), to Build Capacity for the Achievement of Objectives 1, 2 and 3

This project would be designed to be a 'follow-on' initiative, after the end of R2R, and would support achievement of all FSP Objectives. It would have a core focus on addressing current unsustainable patterns of resource use, supporting communities in the FLC area to establish sustainable livelihoods, thereby strengthening the resilience of livelihoods and ecosystems across the FLC catchment area. The project would engage all key stakeholder groups in design, to ensure that proposed livelihood support mechanisms provide realistic opportunities and long-term incentives for people (both men and women) to establish more sustainable patterns of resource use, and to engage more effectively in management of the FLC area.

Two FSP activity areas would *not* be supported under this project: 1) the establishment of IAS control and management; and 2) the development of a sewage treatment system. Given the amount of investment likely to be required to address both IAS management and sewage treatment across the FLC area, it is proposed that these activities be supported under separate, dedicated, projects.

**Objective to which proposed Action contributes:** Objective 1, 2, 3

**Target to which proposed Action contributes:** All Objective Targets, excluding sewage treatment activity areas under 2v) and IAS management activities under 2ii, 2iii and 3i

#### Management Issues:

- Unsustainable patterns of resource use across the Fanga'uta lagoon and catchment area; core issues are: unmanaged use of pesticides and fertilisers in agricultural areas and unsustainable / unmanaged use of mangroves
- Infrastructural development planning does not adequately consider environmental and social impacts / no EIA or by unqualified 'experts'
- Need to strengthen ecosystem based management of the FLC area including monitoring and assessment of ecosystems
- Need for improved awareness and capacity at all levels.
- Need for strengthened management capacity within communities for well-informed local area management, alongside increased consultation by Government agencies with communities, and strengthened partnership between all stakeholder groups.

**Action / Initiative Proposed**

**Anticipated Impact Level**

**Sustainable agriculture across FLC area.** Support could include:

- Skills development for environmentally sound agricultural practices, such as organic, permaculture, agro-forestry etc
- Establishment of certification schemes
- Establish markets / market demand, and / or link farmers to high end markets (including international and tourist)
- improved packaging and marketing,
- Farm management systems / safe use of fertilisers and pesticides
- Enforcement of existing regulations, farm inspections and environmental monitoring including of ground water.
- Awareness raising across FLC communities on impacts of unsafe use of fertilisers and pesticides
- Improve pig keeping in coastal areas / ensure pigs are kept in enclosures, to reduce impacts of free roaming pigs.

**Protection of key mangrove areas and establishment of sustainable harvesting**

Awareness raising at all levels on importance of mangroves for coastal protection and as nursery grounds for fish.

Designate protected areas (potentially through the Land Act) and establish effective management and monitoring systems for those areas. Designate Environment Enforcement Officers to oversee these areas.

Establish community managed 'sustainable use areas' where 'community management committees' control and manage patterns and levels of use of mangroves for tapa, medicinal use and firewood (a similar system to the SMAs could be envisaged). Provide training and resources required for set-up.

Address current issues affecting mangrove areas at Nukuhetulu.

**Eco-tourism, and community based cultural or heritage tourism to support sustainable livelihoods**

Support communities in coastal area to establish eco-tourism, and/or tourism based around cultural and heritage sites such as fresh water springs and archaeological sites. Support would include, training and capacity building for community groups, with a strong focus on women's groups, building skills and capacity for products and events (handicraft, food, dance etc) and for overall business management. Support could also be provided for initial set up to ensure facilities are designed and built with minimal environmental impact, and meet international standards / are designed to be attractive to tourists.

**Work with Tonga Forest Products and Dumps in the FLC area,** to improve environmental management

**Social (1-5) 5**  
**Environmental (1-5) 5**  
**Management (1-5) 5**

<p>and reduce the quantity of leachates escaping.</p> <p><b>Erosion control:</b> area wide support to provide ecosystem based management approach to address erosion in coastal areas around the lagoon.</p> <p><b>Sustainable urban development planning:</b> support development planning which includes sound environmental and social impact assessments</p> <p><b>Build capacity for infrastructural development planning</b> that incorporates EIA by qualified, certified, experts, and ensures there is effective consultation with affected groups.</p> <p><b>Awareness and communication:</b> Support for awareness raising on key sustainability issues, building on the activities initiated under R2R.</p> <p>Ensure Fanga'uta Festival continues as annual event, sustained through partnership between communities, DOE, private sector sponsorship/ engagement and NGO support.</p> <p><b>Build capacity at the community level for Self Help Initiatives</b> including rubbish clean-up, mangrove replanting and nurseries and SMAs.</p>	
<p><b>Lead Responsibility for design / implementation:</b> DOE: FSPS &amp; FSP management committees, following the design and decision making process outlined in the FSP.</p> <p><b>Key Partners:</b> To be determined in design</p>	
<p><b>Resource considerations:</b> To be determined in design</p>	
<p><b>Risks and level of Risk</b> To be determined in design</p>	
<p><b>Proposed Timeframe to initiate:</b> To be determined in design</p> <p><b>Anticipated Timeframe to complete:</b> To be determined in design</p>	
<p><b>Monitoring:</b> To be determined in design, will support on-going FSP monitoring system; and will also need to meet donor requirements</p>	
<p><b>Impact Evaluation:</b> To be determined in design, will support on-going FSP annual evaluation process; and will also need to meet donor requirements.</p>	

**Further Notes and Comments**

If this project is designed during 2017, it will increase the likelihood of a smooth transition following the end of R2R, to ensure results achieved under R2R and momentum/support for implementation of FSP is maintained.

#### Initiative 4: Identify a long-term solution to the treatment of sewage in Nuku'alofa, and for communities across the FLC area

**Objective to which proposed Action contributes:** Objective 2

**Target to which proposed Action contributes:** Target 2v

**Management Issue:** Sewage pollution / nitrification of the lagoon is causing eutrophication and high levels of e.coli bacteria in some coastal areas

**Action / Initiative Proposed**

Identify a long-term solution to sewage related nitrification of the lagoon; Develop a detailed proposal and source funding to implement

Options include:

- Centralised, reticulated sewage system with ocean outfall (long term solution)
- Improved septic systems, to ensure tanks don't leak, and sludge is safely disposed (will reduce current pollution levels)

**Anticipated Impact Level**

*Social (1-5) 5*  
*Environmental (1-5) 5*  
*Management (1-5) 4*

**Lead Responsibility for design / implementation:** DOE: FSPS with the FSP management committees, following the design and decision making process outlined in the FSP.

**Key Partners:** Nuku'alofa Urban Development Sector Project

**Resource considerations:** To be determined through detailed project design

**Risks and level of Risk:**

If managed and built correctly the project will reduce environmental and social risks associated with eutrophication and e.coli pollution.

However the risks associated with the two options are likely different:

- Construction of a centralised, reticulated sewage system for Nuku'alofa and FLC catchment areas will require a substantial budget and significant disruption to Nuku'alofa town as all properties will need to be linked in to the centralised system. A detailed assessment of risks, impacts, costs and benefits should be undertaken as part of assessing feasibility and design of such a system.
- Improvements to existing systems will require a lower budget and be less disruptive, however impacts in terms of reducing eutrophication of the lagoon will be lower, as there will still be nitrates entering in to the groundwater through soakaways.

Details are provided in the technical information brief below

**Proposed Timeframe to initiate:** as soon as possible

**Anticipated Timeframe to complete:** To be determined through detailed design; will be dependent on management option chosen and scale of intervention

**Monitoring** Process to be determine through detailed design; will involve detailed surveys of nitrification of ground water and lagoon, and levels of e.coli pollution.

**Impact Evaluation** Process to be determine through detailed design; will involve detailed evaluation of nitrification of ground water and lagoon, and levels of e.coli pollution

## Further Notes and Comments

### BACKGROUND INFORMATION ON THE IMPACTS OF SEWAGE POLLUTION AND SOLUTIONS FOR SEWAGE DISPOSAL AND TREATMENT ON SMALL ISLANDS

#### 1.1.1 Summary

The issue of sewage disposal on coral-ringed islands and atolls is vastly different than for continental and large land-mass areas. Sewage disposal in large countries focuses on rendering the waste microbiologically safe and removing it from contact with humans, and in some cases recycling it for use in growing as fertiliser. On islands that depend on living corals, microbiological safety and removal from human contact only address part of the problem. On coral reefs, even treated sewage which seeps into the ground finds its way to nearshore areas, lagoons and the outer reef causing major damage to the entire system. There, through algal overgrowth, sedimentation and impacts on coral growth it causes eutrophication. The symptoms of eutrophication include green and otherwise turbid waters, anoxic black patches of bottom sediments, overgrowth of algae (even those species normally found in an area) and loss of coral cover. In turn, these effects can lead to reduced complexity of the coral reef system, loss of benthic organisms (including those used in fisheries), blooms of nuisance algae (e.g. red tides, ciguatera) and increases in the amount of wave energy translating across the reef to an island.

It is not well-understood that sewage treatment and disposal to land will not solve the problem for islands. The reason for this is that sewage treatment renders the waste microbiologically safe, but converts it to fertilizer. It is the fertilizer form of sewage that seeps through the groundwater from septic systems or treatment ponds, finds its way into the nearshore and lagoon areas and causes enrichment. The sewage being generated is far more than just nutrient cycling of existing nutrients on the land as would

have occurred before the population of humans was significant. These days, all the imported foods, including tuna catches from offshore, are aggregating nutrients on land at unprecedented levels; and these nutrients are highly mobile through the groundwater and runoff.

The problems can be by-passed as long as the nutrients entering the nearshore, lagoon and reef can be kept below critical levels likely to cause eutrophication. Water quality standards have been developed to identify when eutrophication is likely to be a risk, or when levels have been exceeded. For example, ANZECC [1-3] and USG Department of Health [4] have developed standards for Ammonia, Nitrites, Nitrates and Phosphates (for risk of eutrophication), and WHO created guidelines for faecal coliform bacteria for human contact [5-7].

Sewage effluents have predictable impacts on the ecology of coral reefs and nearly always represent an environmental and health hazard, but one that is highly dependent on the magnitude and location of sewage inputs. Most of the effects arise through nutrient enrichment, increased sedimentation and changes in topographic complexity. Coral reefs are robust to small inputs, which result in an increase in phytoplankton and benthic algal production. However, moderate to large discharges and widespread and continuous seepage from urban areas results in increased turbidity and sediment loads, increased benthic algal cover, a reduction in coral cover and diversity, and increases in filter-feeding and deposit-feeding organisms. Blooms of toxic micro-organisms and oxygen depletion can also occur. Local increases in fish abundance due to increased algal productivity and topographic complexity have been observed, but losses in other species are also common. In general, impacts of oceanic outfalls discharging small amounts of effluent are likely to be small, provided they are placed in well flushed areas. Ocean outfalls should be developed in preference to any alternatives that might allow sewage to transit nearshore areas and lagoons.

### 1.1.2 Introduction

Coral reefs flourish in clean, oligotrophic<sup>1</sup> waters and so can be stressed by relatively low levels of eutrophication<sup>2</sup> [8]. The release of nutrients into the sea by domestic sewage is a potential threat to many types of coastal marine systems throughout the world, and a particular threat to coral reef ecosystems and the human populations that depend on them [9-11]. Sewage impacts are considered so significant that they have been linked to the global decline in the health of coral reefs [12, 13]. Detrimental effects of sewage inputs have been well documented in the Red Sea [14], Hawaii [15-17], Micronesia [18-20], the Great Barrier Reef [12, 21], the Florida Keys [22-24] and the Caribbean [25, 26]. Despite this long list of studies, it is generally accepted that the problem has been underestimated, due to both a lack of monitoring of effects and reporting of information.

There are a number of reasons why coral reefs are particularly sensitive to nutrient inputs from sewage [11, 27]. Coral reefs generally grow in clear shallow water environments that are naturally low in nutrients, with high productivity being maintained by efficient fixing and recycling of nutrients. This efficiency is maintained within a narrow range of physical variables and there is a low tolerance to changes in environmental conditions. Coral growth and survival are primarily limited by water temperature (which explains their being found only in tropical areas) [28] and clear water with high light penetration (which explains their distribution *within* tropical areas). While increases in nutrients might be expected to be an advantage in terms of increased coral growth and productivity, this does not happen because corals are not usually nutrient limited. Instead, the increased turbidity and sedimentation have a negative effect on coral recruitment and growth, and when severe, causes coral death. Increases in nutrients alter the dynamic relationships between key species on coral reefs and can lead to permanent shifts in the structure of ecological communities. Eutrophication affects coral-reef organisms indirectly by increased growth of micro-algae, leading to increased sedimentation, decreased light availability and rapid growth of opportunistic macro-algae. The performance of corals is reduced and corals are eventually out-competed by the rapid growth of algae. The shift in habitat structure from coral-based to algal dominated substratum can have a major influence on the structure and organisation of other communities associated with coral reefs.

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<sup>1</sup> Environment with naturally very low level of nutrients.

<sup>2</sup> Eutrophication is an increase in the concentration of chemical nutrients in an ecosystem to an extent that increases the primary productivity of the ecosystem. Depending on the degree of eutrophication, subsequent negative environmental effects such as anoxia and severe reductions in water quality, fish, and other animal populations may occur.

The review is organised into two main sections. Section 1.1.3 describes the potential types of impacts that can be expected to arise as a result of sewage pollution and Section 1.1.5 describes the all-important conditions that determine to what extent impacts will occur in any given situation. That is, the conditions under which potentially harmful impacts will occur are strongly dependent on the environmental situation within which sewage is being discharged. The most important of these in the context of islands concerns whether the situation for disposal is a large land mass with narrow fringing sea, or a mid-oceanic atoll or island with extremely limited land mass.

### 1.1.3 Impacts of Sewage on Coral Reefs

The ecological impacts of sewage pollution on coral reefs was comprehensively reviewed by Pastorak & Bilyard [11] and their major conclusions have been supported by additional studies over the last few years [29-32]. All of these studies were undertaken in locations where the conditions differ significantly from those found in small islands, but do provide important insights into the mechanisms involved. Ecological effects of sewage outfalls primarily arise from one or all of three interrelated mechanisms: (i) Nutrient enrichment; (ii) Increased sedimentation; and/or (iii) Changes in topographic complexity. There are additional impacts relating to secondary effects on sand-forming organisms that form part of the structure of reefs (leading to erosion) and effects on the humans relying on the reefs for their livelihoods in the form of ecosystem goods and services.

#### 1.1.3.1 Nutrient Enrichment, algal blooms and toxic micro-algae

Nutrient enrichment is probably the most important consequence of nearshore sewage outfalls and seepage through the land, resulting in a range of direct and indirect effects, depending on the level of nutrient input. Existing algal stands act as a sink to low levels of input, with enhanced primary productivity of benthic algae and few other changes [33]. Moderate levels of input result in an increase in primary productivity of both phytoplankton and benthic algae, with a matching decline in water clarity [17, 34]. Nutrient levels in the water appear not to undergo substantial increases as they are taken up rapidly by phytoplankton and benthic algae. This can mean that monitoring of ambient levels of nutrients in the surrounding water can report 'no measurable change', while significant damage occurs at an ecosystem level. With further increases, dramatic changes in algal species composition occur. For example, in Kaneohe Bay, Hawaii, the green bubble alga *Dictyosphaeria cavernosa*, normally in low abundance on coral reefs, became the major benthic organism on lagoon slopes after years of sewage discharge. Its abundance was enhanced over 10 km from the outfalls in Kaneohe Bay [35]. Another green alga, *Enteromorpha*, is a genus which thrives in tropical marine areas polluted by sewage [36, 37]). Soegiarto reported an association between sewage pollution and growth of *Acanthophora spicifera*, an alien species in Hawaii [38]. Extreme nutrient inputs can result in blooms of nuisance and toxic micro-algae, especially planktonic flagellates [39, 40]. Blooms of toxic benthic dinoflagellates such as *Gambierdiscus toxicus*, the precursor to ciguatera fish poisoning, have also been linked to nutrient inputs. However, not all algae show an increase. For example, a decrease in the cover of coralline algae was observed at a sewage outfall in Zanzibar [41]. Laboratory experiments conducted in that study showed that the growth and calcification of these corallines were negatively affected by the increased phosphates in the water. This has significant ramifications for nutrient inputs in Tuvalu where coralline algae form a significant part of the lagoon and ocean side sand-forming systems. Interestingly, the presence of coralline algae may serve to indicate situations in which sewage inputs do not exceed the capacity of the receiving environment to attenuate them.

Nutrient inputs also have negative effects on corals as a result of a number of indirect and direct mechanisms. Elevated phytoplankton populations stress reef-building corals by reducing light penetration, which adversely affects coral nutrition, growth and survival, through impacts on the zooxanthellae [17]. Also, as benthic algae increase in cover and biomass, they colonise coral skeletons and overgrow living corals [11, 30]. Algae eventually form thick mats killing the underlying corals by blocking light and trapping sediment, which also prevents further recruitment of corals [14, 35, 42]. In Kaneohe Bay, *Dictyosphaeria* colonised the bases and crevices in corals, then migrated up to smother the coral [10, 43]. The relative importance of the different processes causing a loss of corals is not always known, but the reduction in autotrophic production and calcification results in a net erosion of reefs [44].

By another mechanism, bacterial populations inhabiting coral mucous may increase following enrichment and kill coral tissue [45]. In more recent studies, coral diseases and susceptibility to bleaching were found to be increased by nutrient pollution, indicating direct impacts. In Florida Keys, coral diseases doubled and bleaching more than tripled where corals were subjected to levels of nutrients often associated with sewage and agricultural pollution [46]. Interestingly, the recovery time when the pollution was removed was around 10 months, suggesting that actions to remove the pollution should restore coral health. Sewage treatment systems adjacent to coastal coral reefs

must include nutrient removal to ensure that nutrient concentrations, after dilution, are below the low thresholds noted for these oligotrophic ecosystems [30]. According to [47] the thresholds for dissolved inorganic nitrogen (DIN) are around 0.5–1  $\mu\text{mol/l}$  for benthic algal blooms on coral reefs, whereas the soluble reactive Phosphorus (SRP) threshold is around 0.1  $\mu\text{mol/l}$ . This amount of each chemical needs to be generally maintained at a location to support blooms.

A variety of filter and deposit feeding invertebrates also appear to increase as a result of nutrient inputs and increased planktonic production. The growth of sponges, bryozoans and tunicates is favoured by higher nutrients, which out-compete corals for space on the reef [42, 43, 48]. For example, the sponge *Chondrilla nucula* increased and the coral *Acropora palmata* decreased near sewage outfall in Christianstead harbour, St Croix [36]. The tubicolous polychaete *Spirochaetopterus oculatus* and *Capitella* spp. indicated high organic pollution in Kingston harbour, Jamaica [49]. Similarly, the holothurian *Ophiodesoma spectabilis* increased following sewage pollution in Kaneohe Bay, Hawaii [10].

Enhanced algal cover and sewage particles around outfalls often attract grazing fishes [10, 50]. The greater productivity may support larger numbers of grazers in these areas. Studies in Kaneohe Bay also show that planktivorous species, such as *Stolephorus purpureus* and *Pranesus insularum*, dominated assemblages near the outfalls [51, 52]. However, despite greater numbers, the condition of fishes may be reduced near sewage outfalls, particularly as a result of bacterial infections. Reproduction in fishes associated with sewage outfalls is known to be impaired [53] and a variety of histopathological changes have been observed [54].

Nearshore tropical ecosystems are more susceptible to nitrogen loading as the attenuation capacity of the microbial communities is limited by a fragile nitrification link. At the same time, accumulation of organic matter in nearshore carbonate sediments appears to impair their capacity for phosphorus immobilization. In the absence of purifying mechanisms for either phosphorus or nitrogen, limitation for both these nutrients is alleviated and continued nutrient loading fuels the proliferation of nuisance algae [55]. In carbonate-rich environments, eutrophication shifts nutrient regulation of productivity from Phosphorus to Nitrogen [56].

#### **1.1.3.2 Sedimentation**

Increased sedimentation from sewage results from particles contained in effluent, particulate organic matter produced by nutrient enrichment and increased bioerosion near outfalls. Corals generally have a limited ability to reject sediment which lands on the surface of the colony, but can do so by polyp distension, ciliary activity and mucus production. The sensitivity to increases in sedimentation varies among species and by colony acclimatisation; but generally, coral species and colonies associated with exposed reef slopes are more sensitive than lagoonal or inshore species or colonies, though in exposed areas of the reef, this is likely to be compensated by good water movements and result in lower rates of sedimentation. High levels of sedimentation can directly smother corals or cover the hard substratum, inhibiting further coral recruitment [57, 58]. These effects combine to reduce overall coral cover and diversity, and may lead to a species composition dominated by a small number of species resilient to sedimentation. Moderate sediment loads may affect corals by decreasing growth rates, which may be due to the energy expended in actively rejecting sediments, decreased light availability or physical abrasion.

Much of the particulate and dissolved organic matter discharged in sewage effluents is readily decomposed by microbes. However, because corals are living at near their critical tolerance levels for dissolved oxygen, depressed oxygen levels associated with decomposition of sewage organics may constitute another stress associated with nutrient enrichment [10].

#### **1.1.3.3 Changes in topographic complexity**

The construction of sewage outfalls may increase the topographic complexity of the reef, as a result of the physical structure of the outfall itself and the disturbance associated with construction. In some cases, this has resulted in an increase in fish abundance and diversity [59-61]. However, continued increases in sedimentation downstream of sewage outfalls are thought to have the opposite effect, with topographic complexity and diversity decreasing.

#### **1.1.3.4 Effects on sand-forming organisms and erosion**

Although the effects of sewage pollution on corals has been well-documented, there exists relatively less information on the effects on other sand-forming organisms.

Where the nutrient enrichment accompanying sewage pollution leads to overgrowth of non-sand-forming soft algae, including in Maldives the apparent overgrowth of seagrasses, there are smothering effects on corals, calcareous algae and other benthic organisms that are sand-producers. This includes foraminifera, coralline algae and shellfish whose skeletal remains become an important source of the sand being grown within coral reef lagoons and which replenishes and grows islands. Calcareous algae have long been recognised as predominant contributors to coral reef sediments [62].

Erosion has been identified in past studies, e.g. [63, 64], as the main environmental problem on many islands, and is often recognised as such by the residents. In 2004 many of the 21 Maldives islands surveyed identified erosion arrest, correction and/or prevention as their top development priority [63]. In that study erosion was identified by communities as the top priority environmental issue. Some of the perceived problems with erosion can be attributed to natural processes, and are part of the normal seasonal cycling of sediments around the island and do not constitute a threat. In a large number of cases, however, the problems with erosion are real, anthropogenic and result from inappropriately designed coastal developments or from poor landuse practices. To this can be added indirect effects of nutrient enrichment which leads to overgrowth of non-sand-forming algae and seagrasses, smothering of sand-forming communities and binding of the sea floor by the roots of seagrasses that in turn may be affecting bed creep of sediments from the lagoon towards the island (see also [65]).

The problem of nutrient impacts could be far-reaching for small islands and atolls. Hallcock and co-workers [66] suggested that relatively modest levels of nutrient enrichment can suppress coral-reef development and where it has occurred naturally (e.g. upwellings) and has important implications for understanding carbonate platform drownings in the geologic record. Nutrient enrichment enhances productivity of fleshy algae to a greater extent than that of calcareous algae. Thus, overgrowth of calcareous algae by more opportunistic fleshy forms could reduce carbonate accretion in tropical coastlines experiencing increased eutrophication [56]. Bjork et al reported a decrease in the cover of an important group of coral-reef builders, the coralline algae that they suggested might be caused by the outlets of sewage water from Zanzibar town. Laboratory and field experiments showed that both the growth rate and the calcification of these organisms are negatively affected by high phosphate levels, but not by nitrate or ammonia [67]. In Reunion the highest rates of bio-erosion of reefs (as macro-boring and micro-boring rates) was found in areas of nutrient enrichment from the land nearby [68].

#### 1.1.4 Toxicity and human health risks

Faecal pollution in seawater is inferred from the presence of indicator bacteria, primarily faecal coliforms and/or faecal streptococci (includes the enterococci) [69]. Epidemiological studies of water-borne illnesses show, however, that the common disease-causing organisms are more likely the viruses and parasitic protozoa, than bacteria. It has also been found that there are poor correlations between waterborne human viruses and faecal coliforms in marine waters - i.e. faecal coliforms are poor indicators of potential risks associated with contaminated seawaters. In addition to this, there are many pathogens which can survive longer in seawater than the faecal coliforms used as indicators [69], (*Table 1*). Despite these problems, most of our knowledge of health risks associated with faecal contamination in seawater comes from studies based on counts of faecal coliforms. The discussion which follows should be read in the light of these limitations.

*Table 1: Major potential pathogens and indicators of sewage in the marine environment [69]*

*Note that these survival times pertain to organisms in sediments in Sydney, Australia and should only be taken as a broad indication.*

Group	Indicator or species	Time of survival
Viruses	<i>Adenovirus</i>	50 days
	<i>Astrovirus</i>	unknown
	<i>Calciivirus</i>	unknown
	<i>Coronavirus</i>	unknown
	<i>Coxsackie A and B</i>	2 days - 46 weeks
	<i>Echovirus</i>	2 days - 46 weeks
	<i>Hepatitis A</i>	> 24 days

	<i>Poliovirus</i>	2 - 130 days
	<i>Reovirus</i>	> 4 days
	<i>Rotovirus</i>	2 - 34 days
Bacteria	<i>Aeromonas spp.</i>	indigenous
	<i>Campylobacter jejuni</i>	poor
	<i>Enterotoxigenic</i>	5 hours - 2 days
	<i>Escherichia coli</i>	
	<i>Faecal coliforms</i>	2 hours - 2 days
	<i>Faecal streptococci</i>	2 hours - 12 days
	<i>Mycobacterium marinorum</i>	indigenous
	<i>Salmonella spp.</i>	12 hours - 5 days
	<i>Shigella spp.</i>	< 15 - > 70 days
	<i>Vibrio spp.</i>	indigenous / < 6 days
	<i>Yersinia enterocolitica</i>	days - weeks
Protozoa	<i>Cryptosporidium parvum</i>	unknown
	<i>Entamoeba histolytica</i>	unknown
	<i>Giardia intestinalis</i>	unknown
Helminth worms	<i>Ascaris spp.</i>	unknown
	<i>Taenia spp.</i>	unknown

Sewage outfalls or non-centralised sewage inputs represent a health risk through negative effects on microbiological water quality. There are numerous cautionary examples. Siren & Scheuring found faecal coliform bacteria in numbers averaging 11 million per 100 ml in inshore reef and lagoon waters near sewage outfalls in all six district centres in the Trust Territory of the Pacific Islands [70]. The WHO standard is less than 350 faecal coliforms or less than 1,000 total coliforms per 100 ml. In Palau, [19] found faecal coliform levels reached 34 million in polluted waters and also reported high coliform concentrations in oysters and crabs near a sewage outfall. [25] found coliform levels grossly exceeding world standard in Jamaica near a tourist hotel and Wade and co-workers [49] found coliforms in excess of 240,000 in Kingston harbour, Jamaica. Similarly, Dong and others [36] reported high levels in Christianstead harbour, St Croix, while [71] reported relatively low levels in Tahiti. Clearly, behaviour of the sewage is highly variable and local conditions need to be considered.

The combination of enhanced fish numbers and sub-lethal pathological effects of sewage outfalls on subsistence fisheries may also represent a health risk. It is likely that high levels of faecal coliform bacteria accumulate in the tissues of fishes feeding at or near sewage outfalls. The accumulation of fishes in these areas can make them a target for fisherman, particularly in heavily populated areas. Contaminants, such as heavy metals and pesticides, have also been found in the tissues of fishes caught near sewage outfalls [72, 73].

Whether and to what extent these impacts develop in a location is dependent on several important factors that can mean the difference between wide-spread risks to humans and natural systems, or almost no impacts. The modifiers are location, volume of discharge and treatment. For small atolls and islands, the most important of these is location, reviewed in the following sections.

#### 1.1.5 Factors Affecting the Occurrence and magnitude of Impacts

Whether significant impacts occur and their magnitude is primarily influenced by the volume and location of the discharges and the level of treatment of the effluent. By appropriate positioning and distribution of effluent inputs, export of nutrients from the reef environment can be maximised, and the effects of nutrients retained in the reef

system can be minimised. One factor, not normally considered by coral reef practitioners is the effect of dilution and cost-benefit of release in the different parts of a reef system.

#### 1.1.5.1 Location and the dilution factor

As a rule, little or no impacts of outfalls have been observed in well-flushed, non-enclosed reef areas [58, 74]. Conversely, large discharges in bays and lagoons have had major effects. The most well-documented example of these two extremes is the historical discharge of sewage into partly enclosed Kaneohe Bay, Hawaii and the subsequent diversion to an open ocean outfall off Mokapu Point. Kaneohe Bay received major sewage inputs for about 30 years. The effects of this have been well described, including increased phytoplankton and primary productivity [34], reduction in coral cover, diversity and rates of calcification [17, 35] and increased sedimentation, algal cover and filter feeders [17, 43]. Following the diversion, a dramatic decrease in nutrient levels, turbidity and phytoplankton production was observed in the previously affected areas [15]. There was also a corresponding change in benthic community structure, with a major decrease in the cover of the green bubble alga, *Dictyosphaeria cavernosa*, and a doubling of coral cover (mainly *Porites compressa* and *Montipora verrucosa*).

Despite considerable concern, the deep ocean outfalls had much more limited effects (reviewed by [75] in their aptly-named paper “Doomsday ecology misapplied”). Dilution of the effluent plume was extremely rapid in this area, with less than a 10% increase in nitrogen and phosphorus levels on adjacent coral reefs. The increases were found to be well within the range that corals can tolerate. Worst case scenarios put concentrations at 10x less than the values of nutrients known to affect coral metabolism [33, 44]. Suspended sediments were also less than 10% over mean ambient levels, which is unlikely to affect coral settlement, growth or survival. [76] showed no effect of 1,000 g/l of suspended sediments, which is 4 orders of magnitude worse than the worst case scenario for the ocean outfall. In South Tarawa, Kiribati, [74] carried out quantitative surveys at increasing distances away from sewage outfalls placed on the reef crest and at controls, reporting that of 150 measures of impact of physical characteristics, diversity and abundance of corals, algae, fishes and intertidal organisms, 57% showed no impacts; 18% of organisms increased in abundance; and 26% decreased in sewage outfall areas compared with controls. Further, 50% of the recorded impacts were limited to an area within a few metres of the outfall site itself, while 50% extended 100m downstream. It should be noted however, that the outfalls were often leaking within the intertidal area and their pipe-ends placed within the surf zone allowing for materials to be washed back towards the shore. This would tend to lead to greater impacts than if the sewage disposal was truly limited to the high-energy surf zone. Other studies showed very little settlement of particulate matter on bottom [77], no effects on infaunal organisms [78, 79] and an enhanced fish community near the outfall [60, 61].

#### 1.1.5.2 The volume of the discharge

The magnitude of the effects of sewage outfalls increases with the volume of the discharge [58]. Extreme effects, which result in widespread coral mortality, a major increase in algal cover and the production of toxic algae may be avoided by keeping the volume of the discharge small and spreading it over a greater area. By this reasoning the combined effects of several small outfalls may be much lower than that for a single, high volume discharge site. The relative effects of having many smaller discharges affecting a larger area of reef, compared with having one or a few discharges which severely damage a smaller overall area have not been tested. It may be better to focus damage to one area and have most of the reef in near-pristine condition.

#### 1.1.5.3 Treatment of sewage

The advantages of primary sewage treatment have not been well studied for coral reef habitats. Primary treatment of sewage prior to discharge is often recommended, as this reduces the input of nutrients [10] and pathogens [69], see *Table 2* below. However, the input of nutrients will only be decreased if the fractions separated from the sewage are disposed of separately and away from the coral reef, which for atolls leaves only the ocean. Further, where nutrient inputs are small, and directed to exposed, offshore areas, coral reefs may be resilient enough to tolerate the small increases in nutrients. On coral atolls, sewage treatment results in additional environmental problems including land requirements for settlement ponds and pollution of the freshwater aquifers. It has been suggested that sewage be treated in association with pond or lagoon aquaculture. However, extensive pollution from such ventures is inevitable, particularly where such plans require closing of lagoon passes [10]. More recently it has been suggested that macro-algae and macro-algal culture be used to remove nutrients from sewage effluents [80] but this, in itself may also lead to widespread changes in lagoon ecology. The suggestion implies that naturally occurring algae and/or bacteria would not undertake this role within the wild ecosystem without engineering by humans: an unsupported assumption. Mangroves have also been used for this purpose [81, 82], however, for coral reefs this will necessarily involve

discharging in lagoonal areas, which represents a greater problem than untreated sewage discharged into the ocean.

*Table 2: Percent of faecal microorganisms removed by different levels of sewage treatment (Ashbolt, 1995)*

Treatment	<i>Escherichia coli</i>	Salmonella, Campylobacter	Enteric viruses	Giardia cysts
Raw sewage (numbers per litre)	108 - 109	40,000	100 - 15,000	5,200 - 22,700
% Removed by:				
Primary treatment	50 - 90%, 27 - 96%	50 - 90%, 15%	0 - 30%	55%
Secondary treatment	91 - 99%	96 - 99%	30 - 75%, 76 - 99%	99%
Tertiary treatment	99.99%	99.99 - 100%	99.8 - 99.99%	99.8%

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**SUMMARY OF KEY BASELINE INFORMATION, FOR REFERENCE IN DESIGN OF INITIATIVES:**

**ISSUES HIGHLIGHTED IN 2015 STATUS OF FANGA’UTA LAGOON REPORT, AND RANGE OF OPTIONS TO ADDRESS THEM**

This table lists the types of actions that could be undertaken to address key issues affecting the ecosystems of the Fanga’uta Area (FLC). The list is indicative, and other ideas for improvement should be considered. If actions are effective in addressing issues and monitoring shows a change in the conditions in the Fanga’uta Area, the priorities may shift as related problems are resolved (by just fixing one of them) and new issues arise. For example, fixing the inputs of nutrients into the lagoon (from sewage and agriculture) should resolve other issues on algal overgrowth, water clarity and fisheries.

Issues (from Status Report 2015)	Solutions	Actions	Positive Impacts			Issues
			Environment	Social	Management	

Issues (from Status Report 2015)	Solutions	Actions	Positive Impacts			Issues
			Environment	Social	Management	
<ul style="list-style-type: none"> <li>▪ Lagoon Eutrophication</li> <li>▪ Poor water quality</li> <li>▪ Declining Seagrass / Increasing algae</li> <li>▪ Poor fisheries habitats</li> </ul>	<ul style="list-style-type: none"> <li>▪ Export sewage to ocean without seepage through lagoon</li> </ul>	<ul style="list-style-type: none"> <li>▪ Centralised, reticulated sewage system with ocean outfall</li> </ul>	★★★★★	★★★★★	★★★★★	Expensive but best permanent solution; Failure to completely export sewage from catchment may mean other programmes will be less effective
	<ul style="list-style-type: none"> <li>▪ Improved septic systems</li> </ul>	<ul style="list-style-type: none"> <li>▪ Ensure systems don't leak; collect sludge and dispose of in ocean</li> </ul>	★★★	★★★	★★	Short-term solution; Will not work if leak, or sludge is disposed of anywhere within the catchment
	<ul style="list-style-type: none"> <li>▪ Reduce use of NPK fertilisers and pesticides</li> <li>▪ Improve control &amp; management of use of NPK fertilisers and pesticides</li> </ul>	<ul style="list-style-type: none"> <li>▪ Permaculture, agroforestry methods introduced</li> </ul>	★★★★★	★★★★★	★★★★★	Will require demonstration farms and much education
	<ul style="list-style-type: none"> <li>▪ Hydrographic surveys in lagoon to provide scientific information on the impact of water flow on different lagoon areas</li> </ul>	<ul style="list-style-type: none"> <li>▪ Explore options to increase water flow to areas affected by excessive siltation</li> <li>▪ Explore options to remove silt from areas affected by excessive siltation</li> </ul>	★	★★★	★★★	Poor lagoon quality is most likely due to sewage & chemical pollution through groundwater. Any dredging activity should be undertaken with extreme caution due to the risk of damage to habitats, reduced oxygenation of water and changes to water flow increasing erosion risk.

Issues (from Status Report 2015)	Solutions	Actions	Positive Impacts			Issues
			Environment	Social	Management	
<ul style="list-style-type: none"> <li>Lowered water discharge rates at springs</li> </ul>	<ul style="list-style-type: none"> <li>Clean out and maintain springs</li> <li>Examine water usage inland of springs at bores</li> <li>Assess other possible causes for any flow reduction and recommend actions</li> </ul>	<ul style="list-style-type: none"> <li>Clear springs of clogging sediments and repair collection pools and walls</li> <li>Manage water usage in wells inland to ensure sufficient flow to springs</li> </ul>	★	★★★★★	★★★	Broader management of water use may be needed to address problems with springs
<ul style="list-style-type: none"> <li>Low diversity of coastal and catchment vegetation</li> <li>Poor condition of coastal vegetation</li> <li>Increased run-off from land into lagoon</li> </ul>	<ul style="list-style-type: none"> <li>Designate reserve areas</li> <li>Replanting in selected areas</li> <li>Restoration where needed</li> <li>Control / manage invasive species impacts on native vegetation</li> </ul>	<ul style="list-style-type: none"> <li>Designate reserve areas for trees needed for local medicines and traditional uses</li> <li>Replant trees to improve diversity and increase resilience of coasts</li> <li>Assess impacts of invasive species on coastal and catchment vegetation and options for effective control actions. Build capacity for effective IAS control in FLC area.</li> </ul>	★★★★	★★★	★★★	Competing uses and ownership of land may make this difficult

Issues (from Status Report 2015)	Solutions	Actions	Positive Impacts			Issues
			Environment	Social	Management	
<ul style="list-style-type: none"> <li>Erosion risk</li> <li>Uncontrolled reclamations</li> <li>Seawalls</li> </ul>	<ul style="list-style-type: none"> <li>Reporting system for seawalls and erosion</li> <li>Restoration of damaged areas, including mangrove replanting.</li> <li>Improved monitoring and enforcement of existing legislations.</li> <li>Hydrological study to better understand erosion patterns.</li> </ul>	<ul style="list-style-type: none"> <li>Use of EIA in developments</li> <li>Citizen policing of works along the lagoon foreshore</li> <li>Erosion reporting</li> <li>Awareness raising with coastal communities on impacts of seawalls, reclamation and importance of mangroves in coastal protection.</li> </ul>	★★★★	★★★★	★★★★	Competing uses and ownership of land may make this difficult
<ul style="list-style-type: none"> <li>Soils contaminated with chemicals</li> <li>Chemicals migrate to lagoon</li> </ul>	<ul style="list-style-type: none"> <li>Reduce chemical use (fertilisers &amp; pesticides)</li> <li>Introduce economically viable better practices and livelihoods</li> <li>Improve control &amp; management of use of NPK fertilisers and pesticides</li> </ul>	<ul style="list-style-type: none"> <li>Work with Tonga Forest Products and dumps to improve leachates escaping</li> <li>Permaculture, agroforestry methods introduced and support provided.</li> <li>Further assessment of pesticide / fertiliser use across the catchment area.</li> <li>Information / awareness raising provided to farmers on safe agricultural practices and options.</li> </ul>	★★★★★	★★★★★	★★★★	Will require demonstration farms and much public education

Issues (from Status Report 2015)	Solutions	Actions	Positive Impacts			Issues
			Environment	Social	Management	
<ul style="list-style-type: none"> <li>7 Mangrove areas significantly depleted / threatened (hotspots)</li> <li>Several mangrove species in low abundance</li> <li>Loss of fishery nursery areas</li> <li>Increased coastal erosion in areas where mangroves have been lost.</li> </ul>	<ul style="list-style-type: none"> <li>Target hotspots for restoration projects</li> <li>Replanting of low abundance species to ensure diversity</li> <li>Better management of mangrove areas</li> <li>Improved awareness at all levels on importance of mangroves for fisheries and coastal protection.</li> </ul>	<ul style="list-style-type: none"> <li>Mangrove replating projects</li> <li>Improve areas of mangroves constricted from tides or freshwater inputs</li> <li>Culverts where roads constrict water flows Address felling</li> <li>Address land encroachment issues, including reallocation of key mangrove areas, currently given to individuals for reclamation.</li> <li>Awareness raising on importance of mangrove areas for fisheries and coastal protection.</li> </ul>	★★★★★	★★★★★	★★★★★	Some areas already reclaimed; Road constriction of mangroves costly to repair; Community projects recommended
<ul style="list-style-type: none"> <li>Rubbish dumping</li> </ul>	<ul style="list-style-type: none"> <li>Improve proper waste disposal</li> </ul>	<ul style="list-style-type: none"> <li>Public education and attitudes</li> <li>Mechanisms to encourage better waste management at community level</li> <li>Better drainage systems near roads</li> </ul>	★★★★★	★★★★★	★★★★★	<p>Potential benefit of establishing community waste action groups</p> <p>New waste collection payment system and fines should work to improve legal rubbish disposal</p>

Issues (from Status Report 2015)	Solutions	Actions	Positive Impacts			Issues
			Environment	Social	Management	
<ul style="list-style-type: none"> <li>Lack of sustainable, resilient livelihood opportunities.</li> </ul>	<ul style="list-style-type: none"> <li>Establishment of a range of opportunities for communities across the FLC area to strengthen resilience and sustainability of livelihoods.</li> </ul>	<ul style="list-style-type: none"> <li>Assess opportunities and provide support based on key opportunities and needs identified.</li> </ul>	★★★★★	★★★★★	★★★	<p>Livelihood contexts across the area include rural, urban, coastal and agricultural. Establish more sustainable and resilient livelihoods will require both sound assessment of opportunities and threats, and provision of support to build capacity and establish economically viable livelihood strategies.</p>
<ul style="list-style-type: none"> <li>Low level of public understanding of sustainability issues including: use of mangroves, impacts of chemicals, SMAs, sewage impacts, rubbish disposal and ecotourism opportunities; impacts / threats of coastal developments</li> </ul>	<ul style="list-style-type: none"> <li>Increase awareness raising initiatives and education at all levels</li> </ul>	<ul style="list-style-type: none"> <li>School curriculum</li> <li>Public awareness through media</li> <li>Annual Fanga'uta Festival</li> <li>Empowerment of communities, districts</li> </ul>	★★★	★★★★★	★★★	<p>Shifting attitudes will take some time Direct involvement of people in environmental management and sustainable livelihood initiatives is a powerful way to increase awareness and understanding</p>

BASELINE DATA MAPS FROM 2015, FOR FULL DETAILS REFER TO STATUS OF FANGA'UTA LAGOON REPORT

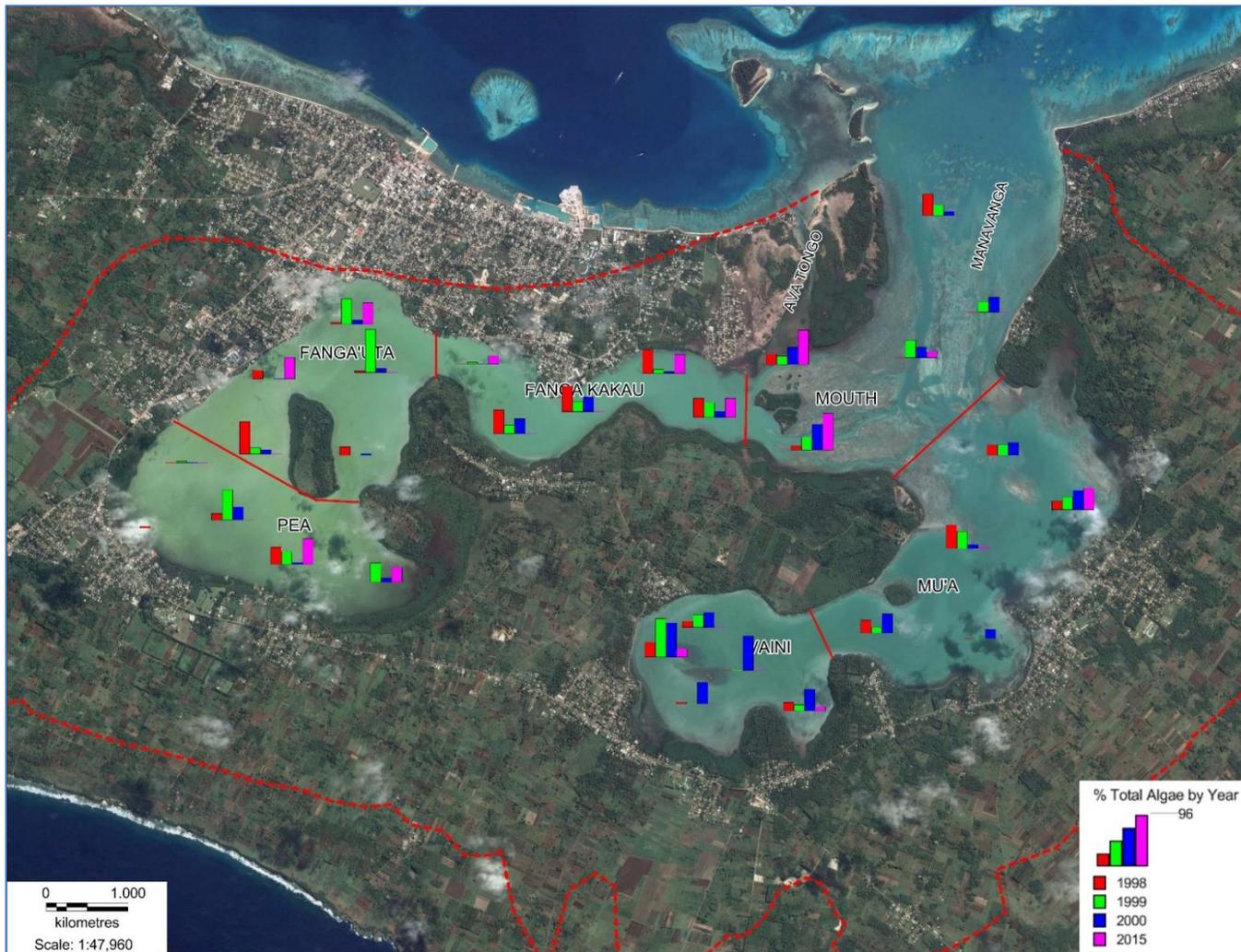
Marine Survey Sites



**Mullet migration route to spawn**



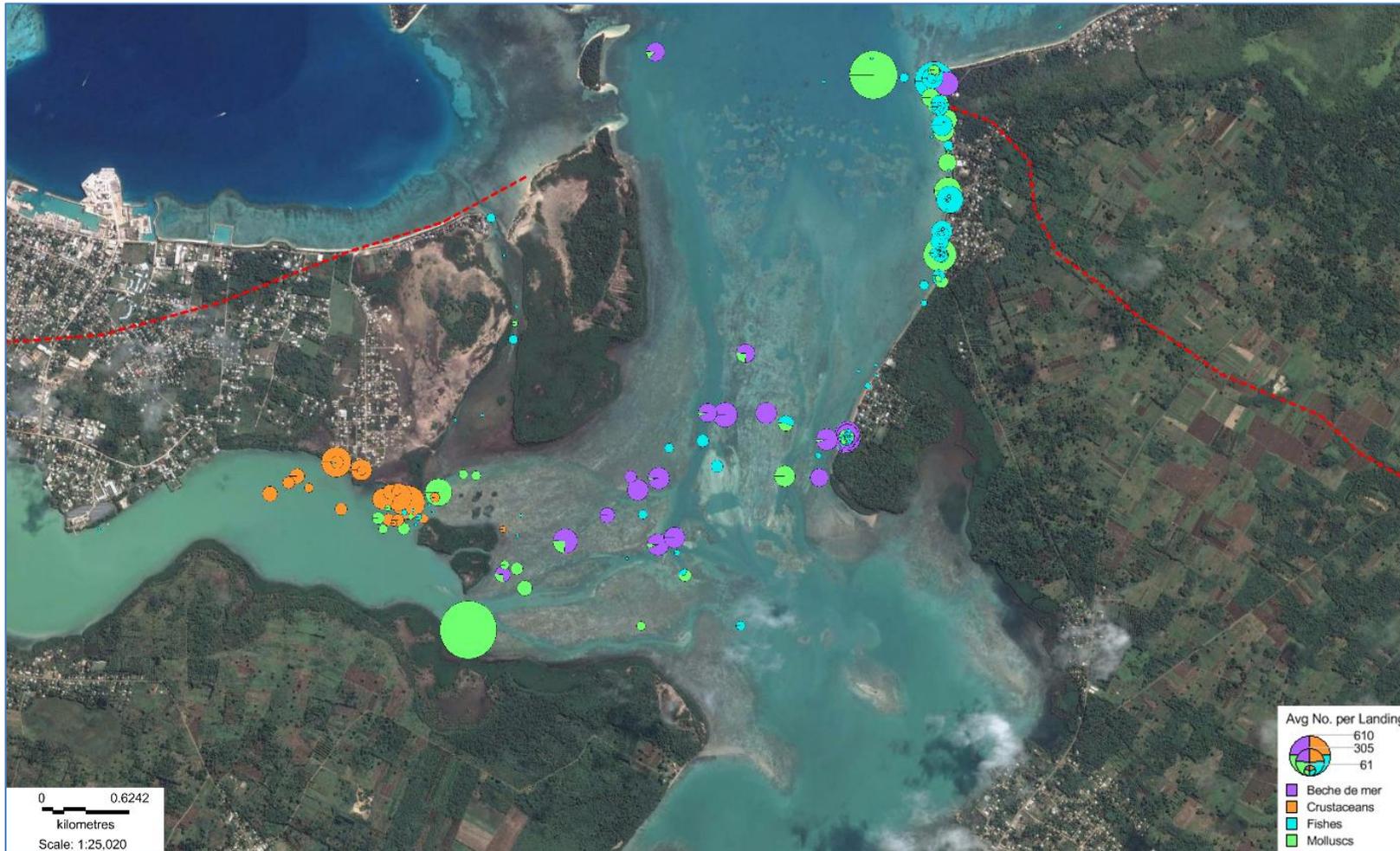
# Algal Cover across the lagoon showing comparative data 2015, 2000, 1999 & 1998



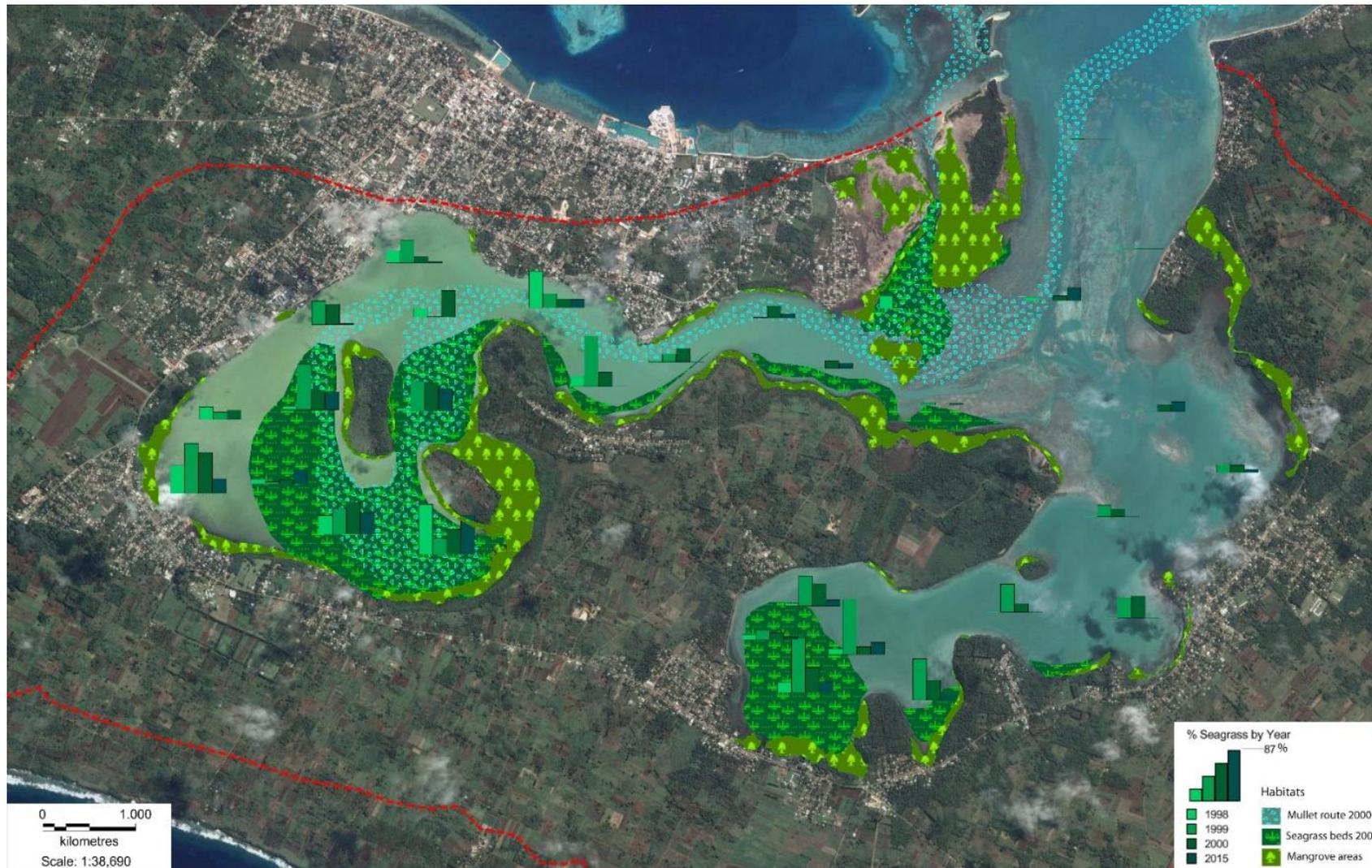
**Seagrass Distribution**



**Fish and Shellfish Catches from creel survey: number per landing of beche de mer, crustaceans, fish and molluscs**



### Seagrass and mangrove distribution showing mullet migration route



### Soil Types at sample sites across the catchment area



